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A Comparative Study on Water Column and Bottom Feeding Habit of Tank Reared Brook Trout (*Salvelinus fontinalis*)

Tanklarda Yetiştirilen Kaynak Alabalıklarının (*Salvelinus fontinalis* Mitchill) Su Kolonu ve Zeminden Beslenme Alışkanlığı Üzerinde Karşılaştırmalı Bir Çalışma

İbrahim Okumuş[1] and Nadir Başçınar[2]

[1)] KTÜ, Faculty of Marine Sciences, Department of Fisheries, 61530 Trabzon, Turkey
[2)] Çanakkale 18 Mart University, Faculty of Fisheries, 17100 Çanakkale, Turkey

Abstract

Feed consumption, growth rate and feed conversion were compared for brook trout (*Salvelinus fontinalis*) feeding in the water column or at the tank bottom. The trial that lasted 120 days was conducted in four 300 l fibreglass tanks with two replicates of 25 fish (mean weight of 45.9 g) in each feeding treatment.

Fish fed in the water column exhibited a mean (SD) specific growth rate (SGR) of 0.93 and reached a final mean weight of 138.9 (28.5) g whereas bottom fed fish had a mean SGR of 0.91 and 135.7 (39.2) g body weight. Overall feed conversion ratios (FCR) and condition factors (CF) were assessed as 1.73, 1.22 for the water column and 1.71, 1.25 bottom fed fish. None of these variables showed statistically significant differences between the treatments. Thus, it seems that brook trout may feed both in water column and at bottom in tank culture conditions and this habit could be utilised for reducing feed waste in intensive commercial trout culture.

Keywords: Brook trout (*Salvelinus fontinalis*), feed consumption, food conversion, growth rate, water column or bottom feeding

Introduction

The farming of salmonids is concentrated on rainbow trout (*Oncorhynchus mykiss*), Atlantic salmon (*Salmo salar*) and a few species of Pacific salmon (*Oncorhynchus spp.*), but other species have also been cultured for ranching and sport fisheries. Several species of the genus *Salvelinus* have been reared for release and to a lesser extent for the table. Brook trout (*Salvelinus fontinalis*) with an annual world-wide production of ca. 750 t is not very popular as a farmed species compared to rainbow trout and Atlantic salmon (FAO, 1999), but it seems to have some potential as second species in rainbow trout farms. For example, in Turkey it has been cultured in small quantities in rainbow trout farms in the Black Sea region.

In previous studies, natural food availability and growth (Cavalli *et al.* 1997), adaptation to seawater (Besner and Pelletier, 1991), growth rates in fresh and seawater environments (Okumuş, *et al.* 1998a), maturity, egg production and egg size (Akbulut *et al.* 1998), duo-culture possibility of brook and rainbow trout (Okumuş *et al.* 1999), effect of stocking density on growth performance and optimum stocking density (Okumuş, *et al.* 1998b) and comparative growth and food consumption of diploid and triploid individuals (O'Keefe and Benfey, 1997, 1999) have been investigated. Jørgensen and Jobling (1990) reported that Arctic charr (*Salvelinus alpinus*) could feed with pellets on the bottom of culture units and exhibited similar growth rates to those fed in the water column. This study was conducted as one of a series of trials evaluating the culture potential of brook trout. The specific objective was to investigate feeding habits of the species under culture conditions by feeding in the water column or at tank bottom. In nature it feeds at or/near bottom (Cavalli *et al.*,1997) and seems to maintain this habit. It is also passive in culture environments in comparison to other salmonid species.

Material and Methods

Fish of 9-10 months were obtained from a commercial fish farm, and 25 fish were placed in each of four 300 L (ϕ = 90 cm) centrally drained circular fibreglass tanks to give replicates of each treatment;

water column and bottom feeding. The tanks which had both fresh (stream) and seawater supplies were half-filled (150 l or 0.15 m^3) with water. They were supplied with 50:50% mixture of unfiltered stream and seawater (i.e brackish water of the Black Sea with salinity of 15.0-18‰) and the resulting salinity of rearing water was around 7.5-9.5‰. Water inflow varied from 2 up to 6 L/min depending on biomass and water temperature. Water temperature ranged from 5.0 to 16.0°C being lowest during the second period of the trial (i.e, February), while dissolved oxygen (7.7 - 9.4 mg/l) did not show pronounced variation. The initial mean (SD) weight of fish was 45.9 (10.5) g. They were acclimatized in the experimental tanks for 7 days prior to the start of the trial and maintained under ambient temperature and photoperiod during the entire trial.

Commercial steam pelleted standard trout feed (crude protein 45 and crude lipid 11-14% of diet) of 2.0 and 3.5 mm, as recommended by the manufacturer, was used and both groups were fed manually 7 days a week twice a day (at 09.00 h and 16.00 h) to apparent satiation by observation of the feeding activity of the column fed fish. The amount of feed given to each tank at each meal was noted, and daily feed consumption was estimated by collecting uneaten feed twice a week. Feeding in the water column group was performed slowly ensuring that majority of the feed was taken by fish before sinking to bottom and feeding was terminated when the fish stopped taking feed. In contrast, in bottom fed group the whole meal was delivered to tank bottom as bulk. Preliminary works and weekly checks revealed that daily feed consumption rates of the groups were similar. Thus, firstly column fed group was fed and the same amount of feed was given to the other group. Both groups had access to feed on the tank bottom. Around half and hour after the meals, the drainpipes were brushed out to remove accumulated faeces and feed wastes from the tanks. In addition to daily feed consumption, mortality and basic water quality parameters namely temperature, salinity and dissolved oxygen values were recorded. Dead fish were weighed and replaced immediately with similar size specimens for maintaining the experimental protocol. Growth rates (live weight gain) were followed by bulk-weighing the fish in each tank to the nearest 5 g at monthly intervals, hereafter termed periods P_0 (initial), P_1, P_2, P_3 and P_4. All the fish were weighed

to nearest 0.01 g individually at the beginning and end of the experiment. In addition, total lengths were measured to nearest 1 mm using a von Boyer trough to calculate condition factors. Weighing and measuring each time was performed after a day of feed deprivation and the fish were handled (weighed or/and measured) individually were anesthetized using 50 mgl^{-1} MS-222.

From the data obtained in the periods, growth performance (increase in weight) and specific growth rates (SGR = $[(\ln W_t - \ln W_0)/t]x100$), changes in biomass ($kg/m^3$), food consumption (FC = [Feed given – Feed collected / Mean body weight] x 100) as % of biomass, feed conversion ratio (FCR= $FC/\Delta W$), condition factor (CF = $[(W / L^3) \times 100]$) and coefficient of variance (CV = [SD / Mean] x 100) were determined. Means of these values were compared using one-way ANOVA and differences at the 5% level were considered significant.

Results

Only one fish from each treatment died and replaced with similar size fish maintained under similar conditions. Fish reached final mean weights of 135.7(39.2) and 138.9(28.5) g with daily growth rates of 0.91 and 0.93% in bottom and column fed groups, respectively (Figure 1 and 2; Table 1). There were no significant differences in growth either between replicates or between treatment groups. In spite of increasing body size (over 100 g) maximum growth rates, 1.4 g/day or 1.3%/day, were observed during the last period of the trial at water temperatures ranging between 9.0 and 16.0°C. The data showed a linear relationship between growth rate and water temperature ($r=0.95$). The trial started with initial density of 7.60 kg/m^3 and reached 23.15 and 22.61 kg/m^3 with increments of around 205% and 198% for column and bottom fed groups, respectively (Table 1). The mean CF values of the groups increased during the course trial, but final values did not exhibit differences between the groups (Table 1).

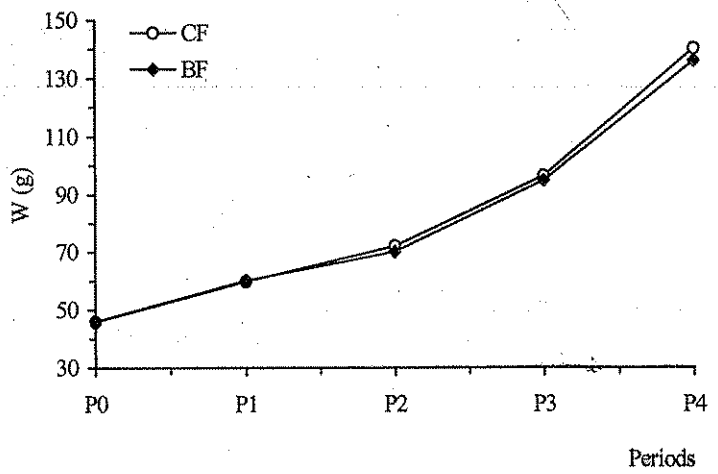

Figure 1. The growth (mean weight) of experimental fish during trial period (CF: column fed; BF: bottom fed).

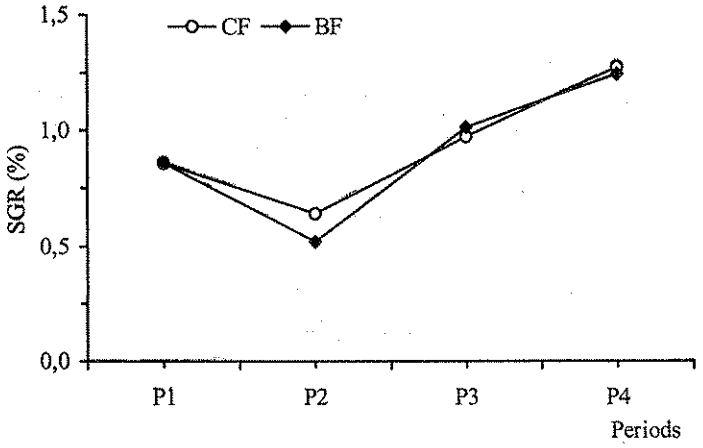

Figure 2. Mean monthly growth rates (SGR) (CF: column fed; BF: bottom fed).

Average food consumption (FC) over the entire trial period ranged from 1.5 to 1.7 % body weight/day with an overall mean of 1.66%, while FCR values varied from 1.5 to 2.1 and 1.4 to 2.0 in column and bottom fed groups (Figure 3 and Table 1). FC varied with water temperature (r=0.85), but did not exhibit any variation with increasing

body weight. FCR showed only slight differences between the groups (Figure 3).

Table 1. Growth rates, condition factor (CF), feed consumption (FC) Feed Conversion Ratio (FCR), biomass (B) and stocking density (D) values of brook trout during the trial ($_i$: initial and $_f$: final values).

	Column Fed			Bottom Fed		
Parameters	Mean	Range	CV	Mean	Range	CV
W_i (g)[1]	45.8	30.7-73.9	22.76	46.0	30.7-58.7	21.24
W_f (g)[1]	138.9	60.9-188.5	20.52	135.7	73.6-286.6	28.89
Growth (g/day)[2]	0.78	-	-	0.75	-	-
	0.93	0.64-1.27	24.73	0.91	0.52-1.24	28.57
SGR (%/day)[2]	1.08	0.92-1.25	8.63	1.10	1.00-1.33	6.91
CF_i	1.22	1.07-1.52	8.73	1.24	1.08-1.46	8.10
CF_f	1.67	1.50-1.73	5.46	1.67	1.50-1.73	5.46
FC (% W/day)[2]	1.73	1.52-2.08	12.47	1.71	1.37-2.01	13.78
FCR[2]	1.15 -3.5	-	-	1.15-3.4	-	-
B_i - B_f (kg/tank)	7.6-23.2	-	-	7.6-22.6	-	-
D_i - D_f (kg/m^3)						

[1]: Mean of two replicates; [2]: Means of successive samplings and two replicates

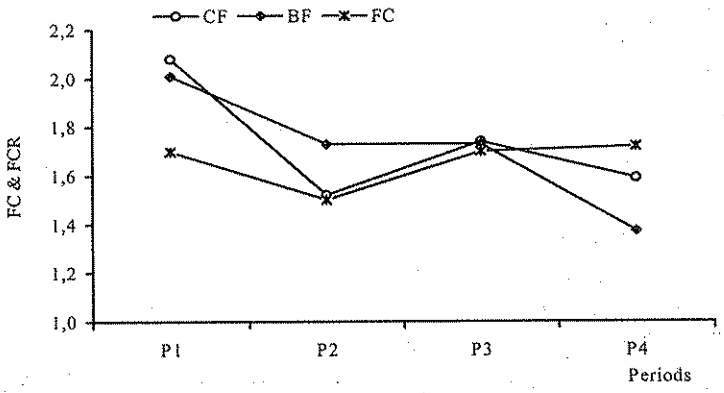

Figure 3. Variations in Feed Conversion Ratio (FCR) and daily Feed Consumption (FC; % body weight) during the trial (CF: column fed; BF: bottom fed).

It is clear that feeding the brook charr in water column or on tank bottom did not have any significant effect on food consumption, growth rate and feed conversion. In another words, fish can completely rely on feed at the tank bottom. The column fed fish had access to feed at bottom as well. This was not prevented. Firstly, shorter and longer term studies conducted in Arctic charr revealed that fish required access to feed at the bottom in order to maintain adequate food consumption and growth rates (Jørgensen and Jobling, 1990). Secondly, the prevention of access to the bottom feed did not seem to have practical value for commercial aquaculture and would probably result in considerable feed wastage particularly when hand-feeding was practised. Relatively high final individual size variation amongst the bottom fed fish indicated that there might be a slight problem in sharing the feed. Inequality in feed allocation or intake may arise from severe competition for a limited resource (here feed), size differences between the members of the stock and establishment of dominant hierarchy due to various reasons (Jørgensen *et al.* 1993; Jobling, 1995). This will increase the size variation within the stock. In present trial, equal access of bottom fed fish to feed might be limited by way of feeding, i.e. not distributing the meal. This may be prevented or lessened by increasing feeding frequency, feeding duration and spreading the feed to a wide area.

Both growth (SGR) and food consumption rates fluctuated during the trial and in spite of increases in body size both variables increased towards the end of the trial reaching maximum values during the last period when the mean water temperature was around 14°C, while minimum values were observed during the coldest period of the trial (Fig. 2). This shows that as in other salmonids, optimum water temperature values of 12-16°C for feeding and growth (Huet, 1971; Bristow, 1992; Okumuş *et al.* 1998b) had pronounced effect on growth. A linear relationship between growth rate and water temperature ($r=0.95$) also supports the effect of temperature on growth. In addition final CF values reaching over 1.2 also indicate near optimum the environmental and husbandry conditions. However, the effect of increasing day length might had some effect on both food consumption and growth as well (Jørgensen and Jobling, 1990; Sæther, *et al.* 1996; Tveiten *et al.* 1996).

Monthly mean values of FC varied between 1.5 and .7% of body weight exhibiting somewhat fluctuations during the course trial (Fig 3). Similar to growth rates FC also seemed to varied with water temperature with values approaching 2.0% at daily temperatures of around 16°C and displaying the lowest values in the coldest period. FCR values also exhibited similar fluctuations for both groups during the trial. They declined (i.e. improved) from initial values of just over 2.0 to 1.6 for column and 1.4 for the bottom fed groups. These FCR values are similar to those estimated in previous studies by Okumuş *et al.*, (1998b, 1999). At present FCR values of under 1.5 with ordinary commercial trout feeds could be regarded as acceptable both from economy of fish farming and environmental points. However, FCR values for commercial standard steam pellets produced in Turkey range from 1.5 to 2.0 (Okumuş *et al.*, 1999).

In conclusion, similar growth performance, feed consumption and conversion values displayed by column and bottom fed groups provide evidence that brook trout completely rely on feed on the bottom and this might have clear implications for commercial culture and feeding practices, such as rearing only in tanks, duo-culture with other salmonids.

Özet

Bu çalışmada, serbest su kolonu ve zeminden beslenen kaynak alabalıklarının *(Salvelinus fontinalis* Mitchill) büyüme ve yem değerlendirme oranları karşılaştırılmıştır. Araştırma, serbest su kolonu ve zeminden besleme grupları için ikişer tekerrür olmak üzere, toplam 300 l'lik dört adet tankta yürütülmüştür. Her bir tekerrürde 25 adet balık olacak şekilde, gruplarda 50'şer adetten toplam 100 balık kullanılmıştır. Balıkların ortalama başlangıç ağırlığı 45.9±10.5 g'dır.

Serbest su kolonundan beslenen balıklarda spesifik büyüme oranı (SGR) 0.93 ve son ağırlık 138.9±28.5 g; zeminden beslenenlerde ise spesifik büyüme oranı 0.91 ve son ağırlık 135.7±39.2 g olarak sergilenmiştir. Ortalama yem değerlendirme oranı (FCR) ve kondisyon faktörü (K), serbest su kolonundan beslenenlerde 1.71 ve 1.25; zeminden beslenenlerde ise 1.73 ve 1.22 olarak tahmin edilmiştir. Bu değerler, serbest su kolonu ve zeminden beslenen gruplar arasında istatistiksel açıdan önemsiz farklılıklar göstermiştir. Sonuç olarak, kaynak alabalığı kültür şartlarında, doğal su kolonu ve zemin veya zemine yakın kesimden beslenme alışkanlığını sürdürebilmektedir görünmektedir ve bu alışkanlık, yoğun ticari alabalık yetiştiriciliğinde yem zayiatını azaltmak amacıyla kullanılabilir.

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